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Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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SPOTTED APPLE-TREE BORER.

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INTRODUCTION.

In connection with a study made by the Bureau of Entomology, under the general direction of Dr. A. L. Quaintance, of several insects whose larvæ bore in the bark and wood of deciduous fruit trees, attention has been directed to the cerambycid species *Saperda crea-ata* Newman, known commonly as the spotted apple-tree borer. This insect occurs locally throughout the apple-growing sections of the central and eastern parts of the United States and is closely allied in habitat, appearance, and behavior with the roundheaded apple-tree borer (*Saperda candida* Fab.) The appelation "spotted" refers to the large white spots on the back of the adult (Pl. II, A–D.) and was probably suggested in contradistinction to the longitudinal dorsal stripes of its better known congener referred to above.

The spotted apple-tree borer appears to be entirely absent from many localities within its general range, while in other localities it is abundant, occasionally replacing to a great extent the roundheaded species. In the vicinity of Lansing, Mich., the writer found it outnumbering *Saperda candida* probably fifty to one. Prof. R. H Pettit, State entomologist of Michigan, in a letter written in 1916, states that about the Michigan Agricultural College they have taken the beetles in so many places and in so many ways that their capture has ceased to excite comment. In certain parts of Iowa and Wisconsin the species has also been reported as common.

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The account which follows is based largely on observations of specimens collected as 1-year-old larvæ in Michigan in 1916 and 1917 and transported in the wood to West Virginia, where they were removed from their feeding places and planted in the trunks and branches of living apple trees of various sizes. In their new position the larvæ continued without intermission to feed, and, so far as could be observed, the insects developed and functioned normally. In the way described a considerable number of adults were reared and from these numerous eggs and future stages of the insect were obtained for life-history study.

HISTORY AND DISTRIBUTION.

The spotted apple-tree borer was first described by Edward Newman in 1838 [1] under the systematic name which it still bears. The first reference in literature to the habits of the species can probably be accredited to L. J. Templin, who, writing in 1877,[2] spoke of injury to apple trees in the West, evidently by this species. In 1880 Prof. Henry Osborne [3] described injury by this insect to apple trees in Iowa, and in 1881 Prof. A. J. Cook [4] wrote of serious injury by the spotted apple-tree borer in Michigan.

FIG. 1.—Distribution of the spotted apple-tree borer. Dots represent definite localities and crosses represent States in which found.

The following definite locality records have been obtained from museum specimens, from the notes of collectors, and from observations made during the present investigations: Tyngsboro, Mass.; Philadelphia, Pa.; Highfield, Md.; French Creek, W. Va.; Lansing, East Lansing, and Detroit, Mich.; Milwaukee, Wis.; Charles City, Manchester, Ames, and Iowa City, Iowa; Edgebrook, Glen View, and Palos Park, Ill.; Beaumont, Tex., and Paris, Ontario, Canada. The species is recorded also from New York, New Jersey, and Ohio. The map (fig. 1) shows the distribution of the insect, so far as known at present, in the United States and Canada.

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[1] NEWMAN, EDWARD. ENTOMOLOGICAL NOTES. *In* Ent. Mag., v. 5, p. 395–396. 1838.

[2] TEMPLIN, L. J. *In* Practical Farmer. Nov. 17, 1877.

[3] OSBORNE, HENRY. *In* Western Stock Jour. and Farmer, v. 10, p. 273–274. 1880.

[4] COOK, A. J. CARBOLIC ACID AS A PREVENTIVE OF INSECT RAVAGES. *In* Can. Ent., v. 13, p. 189–191. 1881.

FOOD PLANTS.

At East Lansing, Mich., the writer found larvæ of the spotted apple-tree borer in abundance in cultivated and roadside seedling apple trees and rather less abundantly in wild crab apple and crataegus trees. Of the three hosts wild crab apple was apparently least preferred. In a letter to the author written in 1916 by Mr. A. B. Wolcott, of the Field Museum of Natural History, Chicago, Ill., it is stated that Mr. Emil Liljeblod has taken the beetles in Illinois from June 12 to July 20 on several species of Crataegus. Chittenden [1] says: "Apple and wild crab are the only plants which it has been observed to injure, but its occurrence has been noted on juneberry and thorn." Slingerland and Crosby [2] give apple, wild crab apple, juneberry, and thorn as the host plants. The present writer has never found the species attacking juneberry.

NATURE OF INJURY.

The injury done by this borer is very similar to that of the common roundheaded species, except that it usually occurs higher on the tree. The common borer almost invariably attacks near the ground, whereas the spotted species distributes its wounds along the central and upper portions of the trunk and among the branches. Small trees and branches, an inch or two in diameter, are most liable to attack. Old wounds made by the borers are frequently marked by slight swellings on the surface, having more or less of a gall-like appearance. Sawdust-like castings are thrown out freely from the burrows.

The borers hatch from eggs that are placed between the bark and wood at the side of punctures which the adult female makes through the bark with her mandibles. As has been pointed out by Osborne,[3] in some cases two eggs are placed on opposite sides of a puncture. Of the numerous egg punctures examined by the writer, about half contained two eggs and the other half only one.

The larva on hatching begins to feed between the bark and wood, eating out an irregularly shaped space at the side of the oviposition scar, meantime thrusting most of its castings out at the opening through which the egg was inserted. The burrow is usually made to extend gradually away from the original scar, and, where two eggs occur, the resultant larvæ sometimes eat in opposite directions around the branch until their burrows meet, thus forming a more or less complete girdle. Toward the end of the first season or in the spring of the second season the larva enters the wood, and, by means

[1] CHITTENDEN, F. H. THE LARGER APPLE-TREE BORERS. U. S. Dept. Agr., Div. Ent., Circ. 32., p. 7, fig. 2. 1898.

[2] SLINGERLAND, M. V., and CROSBY, C. R. MANUAL OF FRUIT INSECTS, p. 193–194, fig. 185. 1914.

[3] OSBORNE, HENRY, op. cit.

of an irregular, tortuous burrow, works its way to the heart of the branch. In the heart it burrows up and down for a distance of from 4 to 6 inches (Pl. IV, A), finally making at the upper end of the burrow a curved extension outward to the inner bark (Pl. I, E, F). Through this the beetle escapes later by gnawing a circular exit in the bark (Pl. V, A, C). Badly infested trees take on a sickly, scraggly appearance, individual branches, and occasionally small trees, dying from the injury.

LIFE HISTORY.

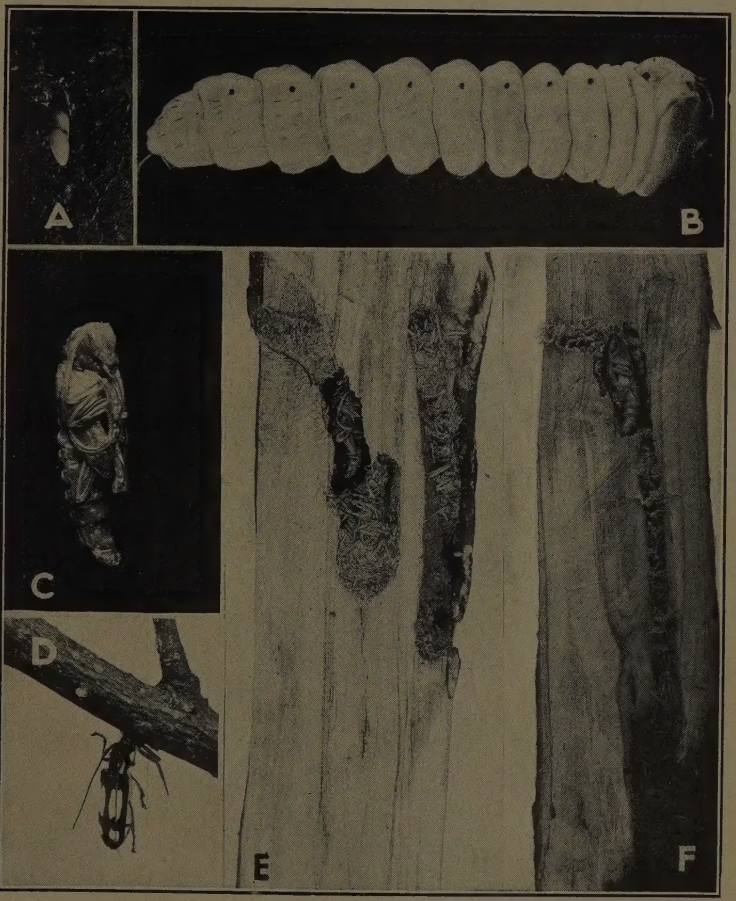
The beetles issue from the wood by day in spring and early summer. In West Virginia they have been observed to appear from May 14 to 31. At East Lansing, Mich., the beetles had apparently all issued on June 26, 1916, but the year following (1917) in the same locality all maturing individuals were still in the pupa stage on June 15.

As would be expected, the beetles appear earlier in the South than in the North. There is probably a variation in the time of emergence of several weeks between the southern and northern limits of the species' range.

After emergence the beetles seek the foliage of the trees and feed, at times rather freely, on the bark of twigs and leaf petioles, and, occasionally, on the leaves (Pl. V, D). Copulation did not take place with any of the beetles observed until about two weeks after emergence. About a week after the first copulation, or three weeks after emergence, oviposition began. Eggs may be laid by an individual female over a period of at least 60 days. The eggs are placed between the bark and wood (Pl. II, E), and hatch in about three weeks. In some cases the larval period is two years, in others three years, and, occasionally, it covers four years. The full-grown larvæ change in the spring to pupæ, which occupy an open space at the upper end of an elongate burrow, usually in the heart of a small trunk or branch (Pl. I, E, F; Pl. IV, B). The pupa stage lasts from four to six weeks. After transforming to adults the insects remain within the pupal cell for from one to two weeks and then gnaw their way out through the bark.

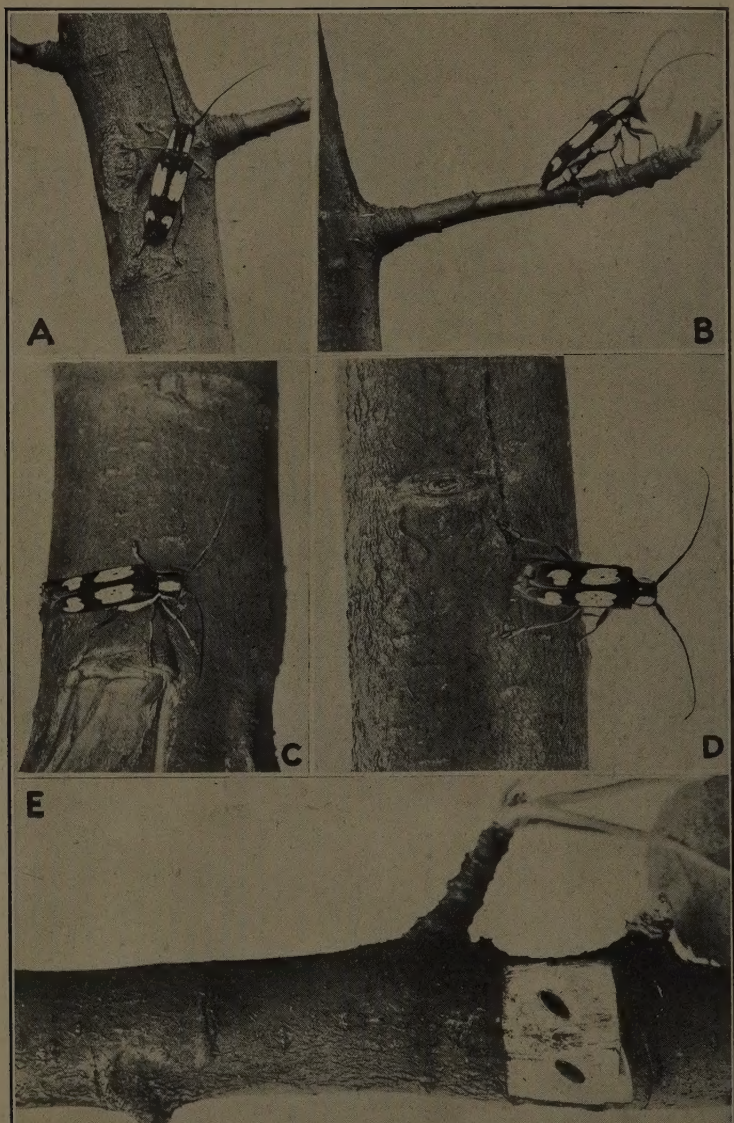
THE EGG.

The egg is elongate, plastic, creamy-white when first laid, but changing to light brown within a few hours. (Pl. I, A; Pl. II, E.) Several specimens removed from their position beneath the bark averaged 4 mm. in length by 2 mm. in width. They were flattened, bluntly rounded at the ends, the surface finely granular and marked by impressions of the wood fiber which pressed them closely on both sides. A free egg found in an oviposition scar was fusiform, slightly curved, both ends tapering to rounded points, 3.7 mm. in length by 1 mm.



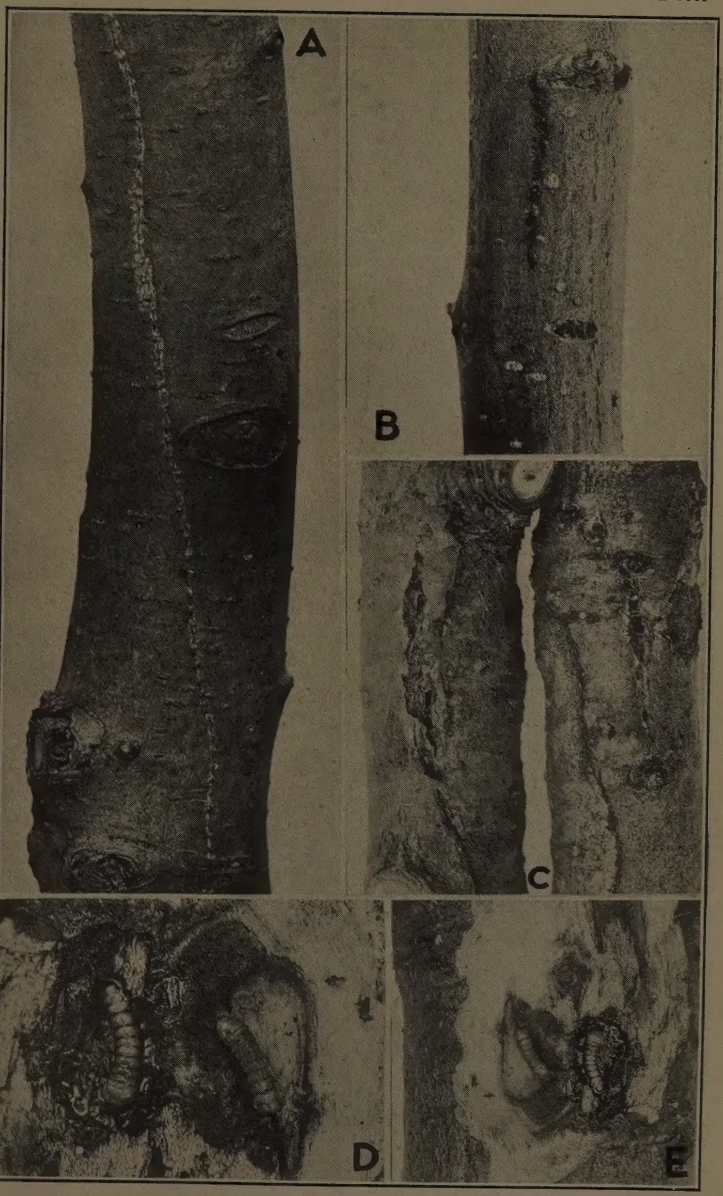
STAGES OF SPOTTED APPLE-TREE BORER.

A, Egg projecting from apple bark; an unusual position; much enlarged. *B*, Larva; much enlarged. *C*, Pupa; much enlarged. *D*, Adult of borer killed by and held in jaws of spider. *E*, *F*, Pupæ in natural position in apple wood.



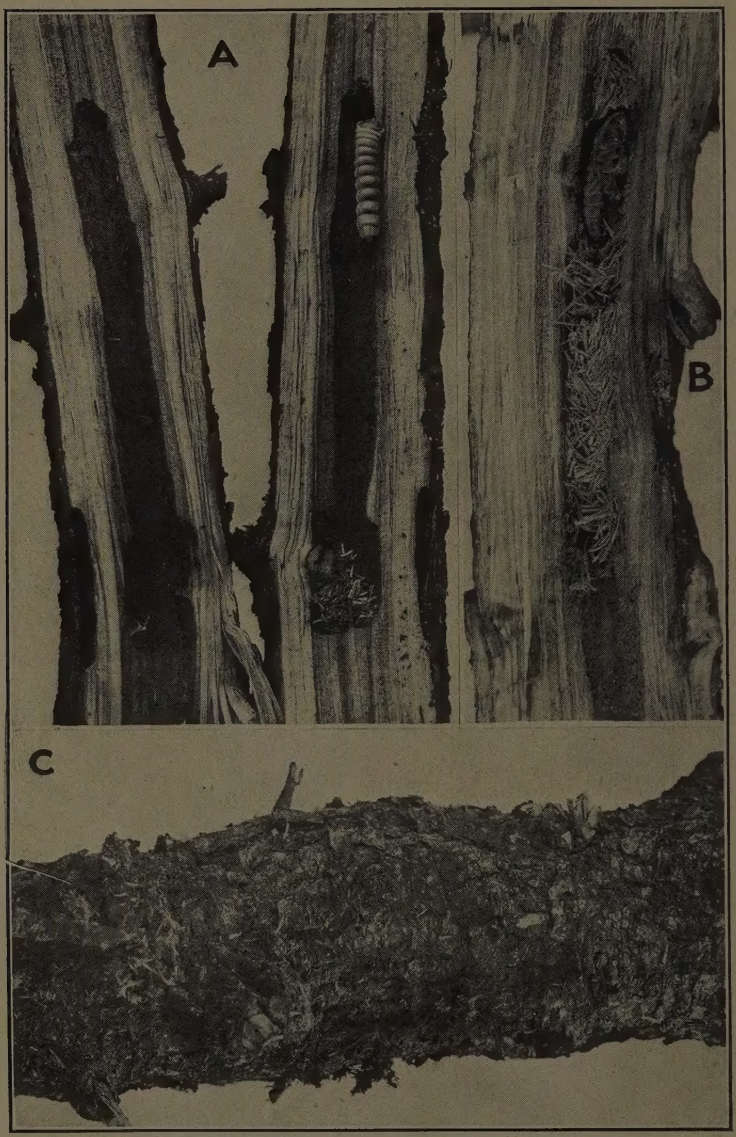
ADULTS AND EGGS OF SPOTTED APPLE-TREE BORER.

A, *B*, Adult female resting on apple branches; slightly enlarged. *C*, Female beetle in act of preparing egg puncture in apple bark; slightly enlarged. *D*, Female beetle in act of oviposition; slightly enlarged. *E*, Apple bark removed to show eggs in natural position.



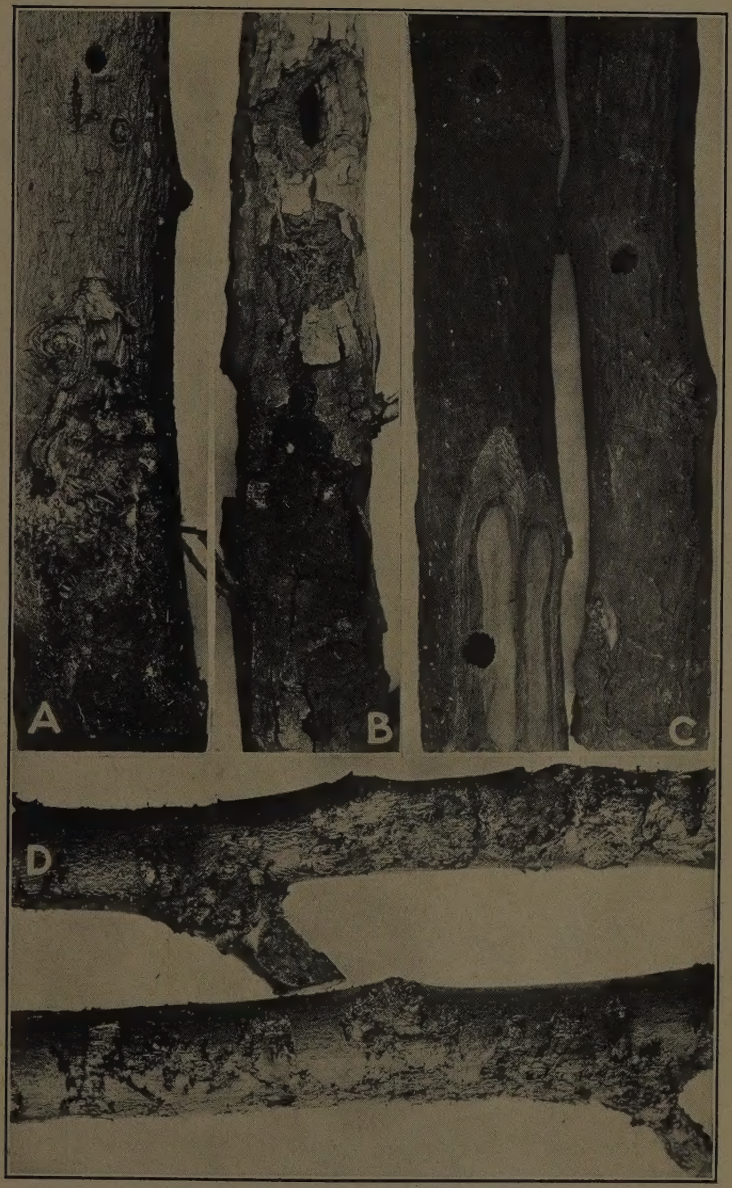
OVIPOSITION SCARS AND LARVÆ OF SPOTTED APPLE-TREE BORER.

A, Long chain of punctures in apple bark accompanying oviposition scar. Eggs were deposited at broad place in chain slightly above the center. *B*, Short chain of punctures accompanying oviposition scar. *C*, Other forms of oviposition scars. *D*, *E*, Pairs of young larvæ found in oviposition scars.



WORK OF SPOTTED APPLE-TREE BORER.

A, Nearly mature larva working in heart of apple wood; natural size. *B*, Pupa occupying natural position at upper end of gallery in heart of apple wood; slightly enlarged. *C*, Section of trunk of young apple tree having a swollen and roughened appearance as a result of injury by borers.



WORK OF SPOTTED APPLE-TREE BORER.

A, Wound of borer and exit hole of adult; natural size. *B*, Wound made by woodpeckers in removing borer from apple wood. *C*, Exit holes of adults; natural size. *D*, Apple twigs showing bark gnawed off by beetles.

in width at the widest point. Eggs in normal position are surrounded by a waxy semitransparent substance, which excludes air and probably shuts out natural enemies.

The eggs are placed between the bark and wood at the side of vertical slits in the bark which the female beetle makes with her jaws. (Pl. III, A, B, C.) These slits, or oviposition scars, may be along the central or upper portions of the trunk or in the branches. They are often accompanied by a chain of shallow punctures extending above and below the oviposition scar, the line of marks resembling the impression that would be made by pressing the cutting edge of a fine-toothed saw against the bark. (Pl. III, A.) In some cases only one egg is placed in a slit and in other cases a pair are deposited, one on each side of the opening. The eggs occupy an oblique position to the line of punctures and are thrust back under the bark from 2 to 3 mm. from the slit at the nearest point. (Pl. II, E.) Four eggs laid on June 29 were kept under observation until July 20 and were then lost by accident, apparently as they were just ready to hatch. This indicates a period of incubation of something over three weeks.

THE LARVA.

The larva (Pl. I, B; Pl. III, D, E; Pl. IV, A) is a whitish, deeply segmented, footless, sparsely bristled grub, having a brown head with black jaws and a broad, convex, papillose, shield-like plate on the dorsum of the prothorax. Full-grown larvæ are from 25 to 30 mm. in length and about 5 mm. in width at the prothorax. The prothoracic segment is widest, the segments tapering to the fourth, and from there being uniform in width to the twelfth. The thirteenth segment narrows to a blunt point. To the casual observer the larva of this species is indistinguishable from that of *Saperda candida*.

In the latitude of West Virginia the larvæ hatch and begin feeding at any time from the latter part of July until some time in September. During the first season the larval excavations are in the form of more or less circular or roughly elongate burrows on one or both sides (according to whether there are one or two larvæ present) of the oviposition scar. (Pl. III, D, E.) At first fine, sawdust-like castings issuing from the oviposition scars mark the presence of the feeding borers.

The second season the borer enters the wood, forming a ragged, winding burrow that leads ultimately to the heart. Here, in the center of the wood, it mines, usually going upward 5 or 6 inches, where it finally pupates at the upper end of the gallery, after having terminated its burrow with an abrupt curve outward to the inner bark. (Pl. I, E, F; Pl. IV, A, B.) As the borer feeds it ejects part of its castings through the bark and packs the rest in unoccupied corners of its burrow. The burrow below the pupal chamber is

packed for an inch or two with excelsior-like strings of wood (Pl. IV, B), evidently as a safeguard against the accumulation of too much moisture while the insect is undergoing its transformation to the adult stage.

Probably the behavior and the metamorphic development of this species are affected to a considerable extent by differences in latitude. No doubt the borer feeds more extensively and grows more rapidly the first season in the South than in the North. In West Virginia, of 16 individuals in which the duration of the larval period was observed, 1 lived in the tree 2 years, 14 lived 3 years, and 1 lived 4 years.

THE PUPA.

The pupa (Pl. I, C, E, F; Pl. IV, B) is characteristic of the family, being creamy white in color with the rudimentary legs, wing pads, and antennæ folded close to the body. In form it is slender, averaging 17 mm. in length by 5 mm. in width. The dimensions of the cell which it occupies (Pl. I, E, F; Pl. IV, B) are only slightly greater than those of the pupa itself. The average size of this cell is about 20 by 8 mm. The restricted quarters of the pupa limit its movements much more than is the case with the pupa of the common borer, *Saperda candida*, whose pupal cell may be 2 inches or more in length. In West Virginia pupation takes place in April, one specimen being found in the pupa stage on April 3. The pupal period lasts from four to six weeks. This stage, also, of the insect's development is probably affected in time limits by differences in climatic conditions due to latitude.

THE ADULT.

The adult of this borer (Pl. II, A–D) is a handsome beetle, the females of which are from 15 to 20 mm. and the males from 12 to 16 mm. in length, the females being much more robust than the males. The upper parts are cinnamon brown with a broad white stripe on each side of the thorax, a large, oblong, white spot, notched at the ends, on the middle of each elytron, and a smaller, comma-shaped, white spot midway between each of these and the apex. There are usually a minute white spot on the thorax just in front of the scutellum and one each on the humeral angles. The sides are white and the underparts of the abdomen and thorax, and the head, antennæ, and legs are brown.

After transforming, the beetles remain in their pupal quarters for several days to harden and then escape by gnawing a circular hole through the bark barrier that has shut them in. (Pl. V, A, C.) The exit hole in the bark is from 5 to 6 mm. in diameter, that of the male being smaller than that of the female.

On escaping, the beetles seek seclusion among the branches where they rest in comparative inactivity during the brighter part of the

day. Near evening they become more active, flying, feeding, copulation, and oviposition being engaged in most freely about sundown, although all these activities extend into the night. The beetles feed rather freely on the tender bark, a favorite place for feeding being the thickened bark around the base of small twigs.

TIME OF EMERGENCE OF BEETLES.

According to Osborne,[1] the beetles appear in Iowa about the middle of June. Wolcott states, in correspondence with the writer, that the beetles have been taken in Illinois from June 12 to July 20. In 1916 the writer found that apparently the last of the beetles had emerged at East Lansing, Mich., on June 26. On June 15, 1917, however, emergence had not yet begun in the same locality. At French Creek, W. Va., beetles issued in 1919 from May 14 to 31, as indicated in Table I.

TABLE I.—*Time of emergence of beetles of the spotted apple-tree borer at French Creek, W. Va., in 1919.*

Date.	Number of beetles.		
	Males.	Females.	Total.
May 14	1	0	1
15	1	0	1
19	2	0	2
20	1	0	1
22	1	0	1
24	1	0	1
25	1	0	1
26	2	1	3
27	1	1	2
28	0	1	1
29	0	1	1
31	0	1	1
Total	11	5	16

It appears from the foregoing data that emergence may take place from the first of May to the last of June, according to locality and climatic conditions. It is very probable that the beetles appear before the first of May in the more southerly localities of the species' range.

OVIPOSITION.

The interesting process of oviposition begins a week or two after the eggs are fertilized. As has been stated, the female usually selects the upper part of the trunk of young trees or branches an inch or two in diameter in which to place her eggs. Occasionally the oviposition scar is in the form of a small, somewhat circular opening in the bark, but more frequently it is a deep, narrow gash in the bark, often accompanied with a more or less prolonged line of pricks extending vertically from one or both ends of the gash. (Pl. III, A–C.)

[1] Osborne, Henry, op. cit.

Oviposition was observed repeatedly and the following may be given as a typical example of one of the more elaborate operations attending the act: About an hour before sundown a beetle was observed to take a horizontal position across the trunk of a young apple tree, about 30 inches above the ground. She began at once to force her jaws their full length into the tender bark. (Pl. II, C.) After the jaws were inserted and withdrawn, the beetle moved sidewise up the trunk for a short distance and again inserted them and thus continued the operation until she had a straight line of pricks about 2 mm. apart. When the line was about 2 inches long she joined several of the pricks together with a deeper furrow and then turned around, as though on a pivot, and inserted the tip of her abdomen into the opening. (Pl. II, D.) She then spent nine minutes in forcing her ovipositor forward between the bark and wood, after which she withdrew her ovipositor, reversed ends, moved across to the other side of the opening and then consumed an equal period of time in again inserting her ovipositor. The two eggs having been placed on opposite sides of the opening, the beetle then took her original position and continued making the chain of pricks until the line was 5 inches in length. She then crawled back among the branches of the tree.

When the oviposition scar was examined closely the two openings where the ovipositor had been thrust in were visible, both being filled with a brownish, semitransparent substance resembling wax. Occasionally a series of punctures is found in which there occur two of the oviposition furrows, each having one or two eggs.

LENGTH OF LIFE OF BEETLES.

Most of the beetles kept for observation were confined in roomy wire-screen cages placed over young apple trees in the field. In this position their length of life was probably something near normal. About one-half of the beetles died within a month after emergence, but a few lived for a considerably longer period. One male attained an adult age of 52 days, while a female lived 93 days. The latter individual died on August 30 and continued to oviposit up to within a few days of its death.

NATURAL ENEMIES.

By far the most effective natural check to the increase of this borer seems to be the woodpeckers. The borers feed in positions easily accessible to these birds and empty burrows are to be found on almost every infested tree, with the marks of the birds around the wounds giving unmistakable evidence of the cause of the borer's disappearance. (Pl. V, B.) During the present studies every attempt to rear larvæ in unprotected trees met with a loss of all the individuals as a result of woodpecker attack. The species of bird

responsible for the loss of the borers was not determined definitely, but all the evidence pointed to the downy woodpecker, *Dryobates pubescens medianus*. It seems probable that the spotted apple-tree borer would be a much more widely known and destructive pest were it not for the constant depletion of their numbers by woodpeckers.

On one occasion a newly emerged female beetle was found in one of the rearing cages hanging suspended in the jaws of a spider. (Pl. I, D.) The spider was captured and was determined later by Mr. C. R. Shoemaker as *Xysticus ferox* (Hentz).

In several cases in Michigan larvæ of the clearwing moth *Aegeria pyri* Harris were found as the sole occupants of burrows made recently by spotted apple-tree borers. There was good reason to believe that the larvæ of the moth had devoured the original occupants, but this could be considered only as an incidental occurrence.

METHODS OF CONTROL.

There is little doubt that in apple orchards which are sprayed with arsenicals for the codling moth and other common insect pests, many of the adults of this borer may be killed incidentally. The fact that beetles feed rather freely on exposed surfaces, especially on the wrinkled bark at the base of twigs where deposits of the poison from sprays collect and adhere, makes them susceptible to this means of control. The beetle has a rather prolonged feeding period before oviposition begins, and this affords a chance to kill it with poison sprays before it has provided for a succeeding generation of borers.

The borers, while small, may be found and removed from the trees very readily by paring away the bark over their burrows with a sharp knife. The burrows can be located without much trouble by the conspicuous castings which are thrown out, and also by the swollen, cankerlike appearance of the affected wood. (Pl. IV, C.) Badly infested branches can often be removed without injury to the tree, and the borers within be destroyed by burning. Breeding places, such as are provided by neglected seedling apple trees, and thorn and wild crab apple thickets, should not be allowed to remain in the immediate vicinity of cultivated orchards.

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